# The biomechanics of Kansal Separator: A '2 in 1' self-secured orthodontic spring separator

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## ABSTRACT

**Background:** An important stage at the very beginning of orthodontic therapy is the separation of teeth where space is created for banding of the molars. A dislodged separator may create problems if ingested or it may get wedged between the adjacent teeth causing acute localized periodontitis. In order to overcome these shortcomings of conventional separators, the Kansal Separator was conceptualized. This separator has been designed as a single device that acts simultaneously on both mesial and distal aspects of tooth, causing adequate separation. In addition to separator's independent 2 in 1 action, the self-locking connecting bar prevents the premature dislodgement of the separator. **Aim:** To determine the force vectors produced by Kansal separator. **Materials and Methods:** A prototype model was created to study the forces produced. **Results:** The separator's unique design is based on sound biomechanical principles that explicate the proof of concept and allows the separator to be distinctly effective and effi cient in variable clinical situations, thus amplifying its uniqueness. **Discussion:** The Kansal Separator, a 2 in 1 orthodontic tooth separator, has a unique design enabling the device to simultaneously separate the teeth on the mesial and distal aspect of the tooth to be banded. **Conclusion:** Kansal Separator's unique design is based on sound biomechanical principles that explicate the proof of concept and allows the separator to be distinctly effective and efficient in variable clinical situations, thus amplifying its uniqueness.

**Key words:** Biomechanics, Kansal Separator, tooth separation

## INTRODUCTION

In orthodontics, the force that is applied to the teeth is analogous to the pharmacologic agents in medicine. So, as important it is for a physician, the good knowledge of pharmacology, a thorough understanding of underlying biomechanical principles is essential to the practice of Orthodontics.

An important stage at the very beginning of orthodontic therapy is the separation of teeth where space is created for banding of the molars. This can be accomplished by various commonly practiced methods of using metal separators, elastomeric separators, brass wire etc., Orthodontic separators are devices, which are inserted in between the teeth of a patient, and kept there for a period of time during which they force the teeth apart so that a gap or a space is created between them to enable the banding procedure.[1,2] The inherent disadvantage of all these commonly used modalities is the frequent dislodgement of these separating devices. A dislodged separator may create problems if ingested or it may get wedged between the adjacent teeth causing acute localized periodontitis. More commonly a failure of separation is a constant source of frustration for the orthodontist at the banding appointment.

In order to overcome these shortcomings of conventional separators, the Kansal Separator* was conceptualized[3] [Figure 1]. This separator has been designed using 0.016 inch A.J. Wilcock stainless steel** as a single device that acts simultaneously on both mesial and distal aspects of tooth, causing adequate separation. In addition to this independent 2 in 1 action, the self-locking connecting bar prevents the

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\*    Patent pending by Dr.Kansal.

\*\*   Registered trademark of A.J. Wilcock Pty. Ltd., Whittlesea, Victoria, Australia.

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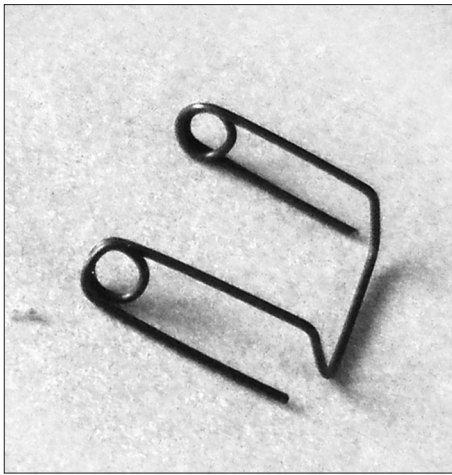
**Figure 1:** Kansal Separator

premature dislodgement of the separator (self-secured feature).

Inspired by the sheer dearth of information on the biomechanical basis of orthodontic tooth separation in the mainstream orthodontic literature, it has been attempted in this article to explicate the biomechanics of Kansal Separator.

## Energy Storage by the Spring

A spring is a device that stores mechanical energy. A helical torsion spring, the type of spring used in the separator, is in the shape of a helix (coil) that, when subjected to twisting about the axis of the coil by sideways forces (bending moments) applied to its ends, twists the coil tighter. This will decrease the bending radii of each coil and bending induced stresses, so generated, will try to unwind the spring.

The energy stored in any spring, upon activation, is potential energy. This potential energy differs from kinetic energy because it has the potential to do work, but is not doing work at the time. It is stored by increasing the tension of the spring, which just means making it tighter. The amount of energy stored in the spring is directly proportional to the degree of activation of the spring. To release the energy, tension must be let off the spring, at which time it quickly reverts to its original position. This means that the spring unwinds to the position in which it has the least potential energy and in which there is the least possible tension on the spring. During this process, the potential energy is released in the form of pressure the spring exerts on the object (in this case a "tooth") to which it is attached or secured. So, the potential energy stored in the spring is converted to Kinetic energy, which is simply the energy that is doing work.

## REVIEW OF LITERATURE

Orthodontic separators are devices, which are inserted in between the teeth of a patient, and kept there for a period of time during which they force the teeth apart so that a gap or a space is created between them to enable the banding procedure.[1,2] An

ideal separator is one which gives rapid maximum separation, without patient discomfort and no separator loss. In addition, it should be hygenic and should not make teeth sensitive to band-seating pressure.[4]

Currently various devices that can be used to create space between adjacent teeth include elastomeric modules, plastic separators, twisted brass wire and metal spring devices such as Kesling separators.[5]

Most of the currently available separators have a major drawback that they dislodge from their position once space is created.[6] Study by Cureton and Bice has shown a patient dislodgement rate varying from 25 to 50% for elastomeric, spring separator and Neet separators over a of 9-12 days evaluation period.[5]

A separator may be required to maintain the "separated" inter-proximal space for a duration longer than 48 h especially in patients where an appliance needs to be fabricated in a lab after band pinching and band transfer. Davidovitch *et al*. have reported that if a separator gets dislodged or if it is removed, 82-95% of the baseline contact point tightness was achieved in 24 h.[7]

Patient discomfort with the separators is also a problem. Ngan *et al*. in their study have reported patient discomfort when molar separators are placed.[8] Bondemark *et al*. in their study have reported an increased discomfort with elastomeric separators as compared to spring separators.[9] These separators also have a tendency to injure the gingiva if left for too long.[10]

No literature is currently available on the biomechanics of separators.

## Principle Involved in Kansal Separator

The Kansal Separator is a single device separating both mesial and distal aspects of tooth simultaneously, adequately yet independently ("2 in 1" feature) and has a self-locking connecting bar for prevention of premature dislodgement of the separator (self-secured feature). This separator acts like a "2 in 1," Self-secured Orthodontic Spring separator and is referred as the "Kansal Separator."

The Kansal Separator consists of one right-hand and one left-hand wound spring coil sections which are connected together, and are working in parallel [Figure 1].

When the separator is engaged, the spring coil generates forces in defined directions. Some components of the force applied by the spring assembly (mesial/distal) are counter balanced by each other and the resultant forces in lateral (horizontal) directions pushes the two adjacent teeth such that the space is created between the mesial and distal surfaces of the desired teeth, thereby leading to a successful "tooth separation."

The spring assembly (mesial/distal) produces forces in two ways:

1. Wedging Action of Spring Assembly ($F_w$)
2. Lateral Action of the Spring Assembly ($F_L$).

## Wedging Action of Spring Assembly ($F_w$)

When the separator is placed in the embrasure area of the tooth, the occlusal leg is called bend over (BO) arm which comes over the contact area (CO) of tooth $T_A$ to be separated. The gingival leg called bend under (BU) arm comes below the contact area (CO) as shown in [Figure 2]. On the distal side [Figure 3], the wedging force $F_w$ is exerted by bend under (BU) arm on the contact area (CO) of the tooth to be separated $T_A$ and the adjacent tooth $T_B$, The cross-section of the wire of BU arm is represented as circle $C_1$ with radius $R_1$ in Figure 3. For ease of simplicity, force $F_w$ (exerted by the spring on BU arm) and its horizontal component acting on tooth $T_A$ are also shown in Figure 3.

The spring will push the BU arm in the vertical direction with a force $F_w$ given by

$$F_w = k\Delta y$$

Where,
$\Delta y$: Is the linear vertical displacement of the bend under (BU) arm from state of rest to the activation state.

k: Is the spring constant which depends on the material and the diameter of the wire used as well as the radius of the helical coil.

As the bend under (BU) arm is wedged between two teeth $T_A$ and $T_B$, force is exerted on both sides of the adjacent teeth along a direction perpendicular to the tooth surface at the contact. This force (say $F_D$) on both teeth has to be such that the sum of their vertical components should be equal to $F_w$. Thus

$$F_w = 2F_D \sin\theta,$$
i.e. $F_D = F_w / (2 \sin\theta)$

Thus the horizontal force exerted by the BU arm on tooth B as shown in Figure 3 is given by

$$F_H = F_D \cos\theta = (F_w/2) \cot\theta$$

The total horizontal component $F_{H\ TOTAL}$ exerted by bend under (BU) arm and BO arm, on tooth B will be

$$F_{H\ TOTAL} = F_w/2\{ \cot\theta_{ABOVE} + \cot\theta_{BELOW}\}$$

Here angles $\theta_{ABOVE}$ and $\theta_{BELOW}$ are the half-angles of the wedges made above and below the contact point of teeth A and B. The same force $F_{H\ TOTAL}$ will act on tooth A in the horizontal left direction, however it will be balanced by the force acting on tooth A due to the BU and BO arms between teeth $T_C$ and $T_A$. Further the vertical forces exerted by BU and BO arms on each contact areas will also be balanced. Thus there will be net horizontal forces acting on $T_B$ and $T_C$ toward directions away from $T_A$, creating the required space as shown in Figure 4.
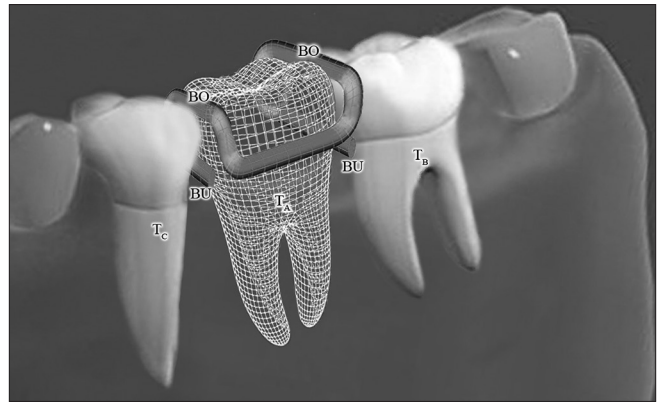


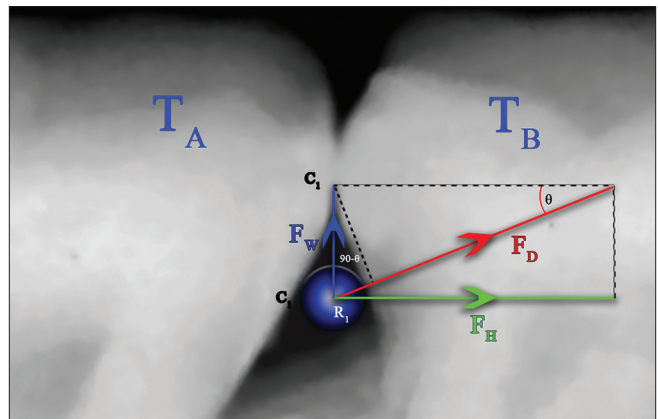**Figure 2:** Kansal Separator in position for Separation of tooth $T_A$ for banding



**Figure 3:** Components of wedging force ($F_w$) acting on the distal contact area
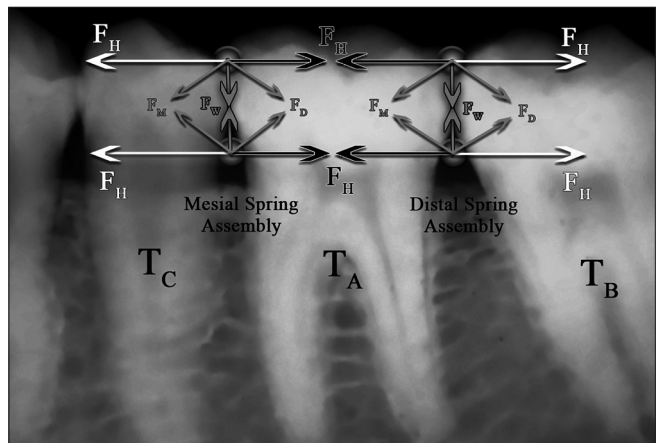


**Figure 4:** Clinical significance of wedging action by spring coil; $F_H$: Horizontal component of force exerting the separating force; $F_M$ and $F_D$: Forces exerted by the BU and BO arms on the teeth on the mesial and distal sides

Thus the mesial and distal spring assemblies act simultaneously and independently to achieve the desired "Separation" for placing the orthodontic band and the total force or torque generated by the Kansal Separator is the total force generated by the sum total of force exerted by mesial spring assembly and distal spring assembly.

## Clinical Significance of Wedging Action by Spring Coil [Figure 4]

1. The total vertical component $F_{W\ TOTAL}$ exerted by bend over (BO) arm and bend under arm (BU) of the Distal/Mesial Spring Assembly; is counter balanced by each other. Thus the resultant $F_{W\ TOTAL}$ of the Distal/Mesial Spring Assembly would be theoretically = 0

2. The total horizontal component $F_{H\ TOTAL}$ exerted by bend over (BO) arm and bend under (BU) arm of the Distal Spring Assembly, is acting horizontally on the proximal wall of adjacent teeth $T_B$ such that the desired separating forces are generated and space is created between $T_A$ and $T_B$

3. Similarly, the total horizontal component $F_{H\ TOTAL}$ exerted by bend over (BO) arm and bend under (BO) arm of the Mesial Spring Assembly, is acting horizontally on the proximal wall of adjacent teeth $T_C$ such that the desired separating forces are generated and space is created between $T_A$ and $T_C$

4. The net horizontal force acting on tooth $T_A$ due to Distal and Mesial Spring assemblies is zero and thus tooth $T_A$ remains stationary while as discussed above, the horizontal components of the forces $F_M$ and $F_D$ generate separating forces on the adjacent teeth $T_B$ and $T_C$ such that adequate space is created for banding procedure on the desired tooth $T_A$.

## Lateral Action of the Spring Assembly ($F_L$)

There are two spring coils present in the separator. One is present in the mesial spring assembly and the other is present in the distal spring assembly. The number of coils in the spring creates a horizontal distance H between the bend over (BO) arm and bend under (BO) arm when the spring is at rest position. The bend over (BO) arm is placed toward the "Self-Secured Connecting Bar" and the bend under (BO) arm is placed away from the "Self-Secured Connecting Bar."

The horizontal distance H, between the BO arm and BU arm increases as the number of coils increases. When the Kansal Separator is placed on the teeth, the BO arm and BU arm are placed under compressive stress and the horizontal distance H, between BO and BU arm decreases in active state [Figure 5].

Thus when the Kansal Separator is placed between the teeth, the compressive stress is relieved and a counter-directed force is applied against the mesial and distal walls of adjacent teeth $T_B$ and $T_C$, [Figure 6] thereby creating adequate space for placement of orthodontic bands in the desired tooth $T_A$. Considering the forces exerted by mesial spring assembly, the lateral action of the spring coil is directly proportional to the compression of the coil in the horizontal direction.

$$F_L = k'\Delta x$$

Where $F_L$ is the force acting due to lateral action of the spring coil of the mesial spring assembly.

$\Delta x$ is the linear horizontal displacement in X' direction of the



**Figure 5:** Lateral action of the Kansal Separator: Lateral compression of spring when placed on the contact area
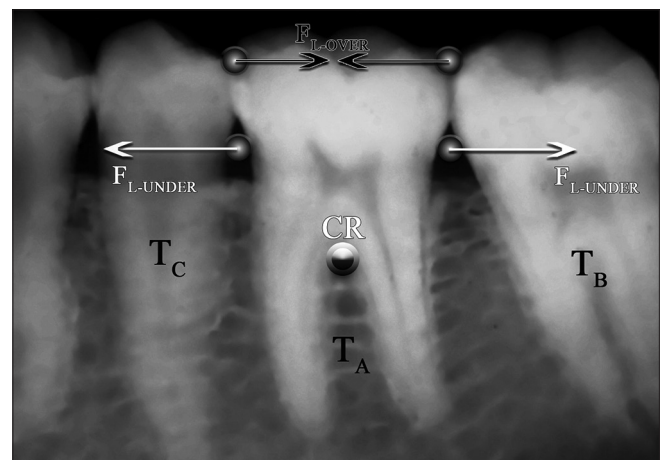


**Figure 6:** Lateral action of the Kansal Separator; $F_{L-OVER}$: Horizontal forces that are counter balanced; $F_{L-UNDER}$: Horizontal forces that generate the desired separating force

bend under arm (BU) and bend under (BU) arm from state of rest position to the activation state.

k' is the spring constant of the spring coil in the horizontal direction.

The BO arm which comes over the contact area and exerts a horizontal force $F_{L\ OVER}$ in the direction towards the tooth $T_A$ where the orthodontic band is to be placed.

The BU arm comes under the contact area and exerts a horizontal force $F_{L\ UNDER}$ in the direction toward the adjacent tooth $T_B$ which needs to move laterally so that space is created for placing the orthodontic band in desired tooth $T_A$.

As the separator is based on principle of double torsion spring and consists of mesial and distal spring assembly, the same forces are generated by distal spring assembly.

## Clinical Significance of Lateral Action of the Spring Coil

The horizontal forces $F_{L\ OVER}$ exerted by the bend over (BO) arm of mesial and distal spring assembly on the tooth $T_A$; are directed toward each other and are therefore counter balanced. Thus the desired tooth $T_A$ on which the orthodontic band is to be placed remains stationary.

The horizontal forces $F_{L\ UNDER}$ exerted by the bend under (BU) arm of the mesial and distal spring assembly on the tooth TB and TC respectively are directed away from each other. Thus a horizontal separating force is exerted on mesial and distal walls of adjacent teeth $T_B$ and $T_C$, thereby creating adequate space between tooth $T_A$ for placing orthodontic band.

As the resultant horizontal force is applied by BU arm, the active resultant horizontal force $F_{L\ UNDER}$ is closer to the center of resistance (CR) of the tooth thereby creating a more effective bodily movement of the teeth $T_B$ and $T_C$ [Figure 7].

## Self–secure Action of the Separator

As the space is created, the dual forces, that is the forces generated by wedging action and the lateral action of the spring coil decreases rapidly and the prototype tends to become loose. Here the self- secured connecting bar comes in action. It connects both the mesial and distal spring assembly hence resisting the dislodgement of the prototype. The self-secured connecting bar is located in the undercut area below the maximum bulge of tooth in the palatal/lingual side of the tooth, which causes the resistance to dislodging forces in all directions and keeps the prototype in mouth even after the it has completely separated the tooth and has become loose.

This self-secure action also prevents the eventual wedging of the separator interdentally. This is in part effected by the presence of two springs interconnected by the self-secured
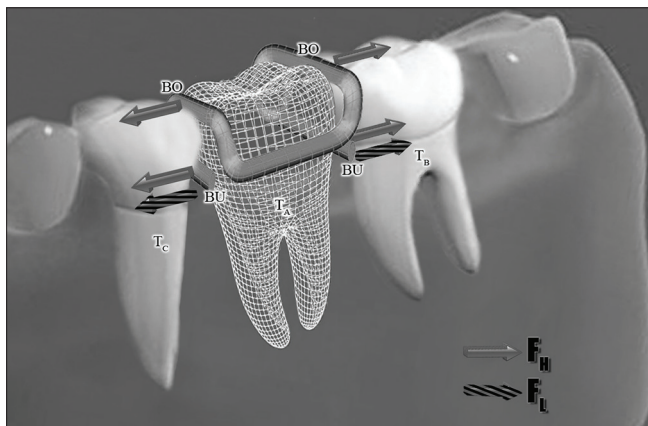


**Figure 7:** Resultant effective horizontal forces exerted on the adjacent teeth; $F_H$: Resultant horizontal forces due to wedging action of Kansal Separator, $F_L$: Resultant horizontal forces due to lateral action of Kansal Separator

connecting bar. So any wedging force on one side of the separator is resisted by the other spring assembly. In the event of wedging force being applied on both sides simultaneously, the gingival wedging is prevented by the presence of the interconnecting bar in the lingual cervical undercut.

## DISCUSSION

The Kansal Separator, a 2 in 1 orthodontic tooth separator, has a unique design enabling the device to simultaneously separate the teeth on the mesial and distal aspect of the tooth to be banded. Moreover the additional self-secure feature gives the orthodontist the control over the amount of time lapsed between the separator placement and the banding appointment.

## CONCLUSION

Kansal Separator's unique design is based on sound biomechanical principles that explicate the proof of concept and allows the separator to be distinctly effective and efficient in variable clinical situations, thus amplifying its uniqueness.

## ACKNOWLEDGEMENT

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